Province of
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Ministry of
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A MOBILE WEATHER MEASUREMENT SYSTEM

by

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FOREWORD

The development and evaluation of the equipment and techniques described herein occurred primarily while the authors were employed by the Chemical Control Research Institute (Ottawa) during the decade 1970-79. Since then, this system of on-site weather measurement has been adopted and/or modified for use by several research and operational establishments across Canada. The support and encouragement of the Canadian Forestry Service, Environment Canada, was fundamental for its evolution and subsequent acceptance.

ABSTRACT

During recent years, the need for detailed information during forestry investigations and operations has prompted the development of an increasing variety of simple, effective, and versatile monitoring methods and devices. One of these, a single-person mobile weather station for location at remote and temporary sites, is essential during the application of pesticides for forestry purposes. The system described comprises a 12 m telescopic aluminum mast mounted by special bracket to the front bumper of a 4-wheel drive vehicle, a variety of high quality weather instruments and a digital weather computer. Operated as an on-site weather station during aerial spray experiments, the system functions extremely well. Its potential for modification for other related purposes is also considered very good.

RESUME

Au cours des dernieres annees, la necessite d'acquerir des renseignements detailles lors de recherches et d'operations forestieres a mene a la conception d'une gamme toujours croissante de methodes et de dispositifs de controle simples mais efficaces qui peuvent avoir des utilites tres diverses. C'est ainsi que fut cree un poste meteorologique mobile qui peut etre commande par une seule personne et qui peut servir en des lieux eloignes ou sur des chantiers temportaires. Indispensable lors d'utilisation de pesticides a des fins forestieres, l'appareil se compose d'un mat telescopique en aluminium de 12 m, installe a l'aide de fixations speciales au pare-chocs avant d'un vehicule a quatre roues motrices, et d'un groupe d'instruments meteorologiques de haute qualite, notamment un ordinateur meteorologique a affichage numerique. Utilise comme station meteo "sur place" pendant les essais d'arrosage, le dispositif a fonctionne de facon excellente. Les possibilites de l'utiliser tel quel ou modifie a d'autres fins connexes sont tres bonnes.

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INTRODUCTION

Measurement of meteorological conditions in forest environments has been a common practice in forestry research and operations for many years. For example, determinations of fire hazard (Ontario Ministry of Natural Resources 1974), abiotic influences on growth rates of trees (Kramer and Kozlowski 1979), and the population dynamics of insect pests (Ives et al. 1968, Greenbank et al. 1980, Morris 1963, Wellington 1954) would be either incomplete or impossible without the recording and assessment of key meteorological elements.

Generally, the equipment and standards of the Atmospheric Environment Service (AES), Environment Canada, have served as guidelines for these measurements. The basic weather station usually includes a maximum-minimum thermometer and a recording hygrothermograph enclosed in an instrument shelter, a cup anemometer and vane for determining wind speed and direction, rain gauge, barometer, and sunshine recorder (AES 1978, Geiger 1965, Petterssen 1958).

During the past two decades, knowledge of weather conditions has become particularly important in forest insect spraying operations (Armstrong 1975a, b, 1977) because the success of aerially dispersed small (ca. 20-150μm Mass Median Diameter) droplets is largely dependent upon meteorological conditions during application. Despite the need for knowledge of local conditions and weather trends during spray treatments, the remoteness of many designated forest blocks and the temporary nature of the on-site installation often discourages the collection of appropriate weather data. Accordingly, data are not always recorded adequately enough to contribute to interpretation of treatment results.

In eastern Canada, for example, weather conditions at or near spray blocks are usually determined either by aerial reconnaissance using some instrumentation and pilot judgement, or by combination air and ground observations. At best, ground support staff use hand equipment (sling psychrometer, Dwyer wind meter) rather than establish temporary AES-type stations. However, the demand for complete "spray weather" records has grown with the environmental concerns expressed during recent years and, as well, with the obvious need to optimize spray efficiency against target pests using reduced quantities of toxicant (Prebble 1975). A complete temporary weather station has therefore become essential for many spray operations.

Canadian Forestry Service staff involved in aerial spray experiments have utilized a variety of meteorological instruments and equipment during the past 20 years. In keeping with the

logistical needs of each project, mobility of the ground weather station has been an important consideration in the selection of instrumentation. Equipment and instruments must be reliable, light weight, durable, readily transported by small- to medium-size vehicles, and quickly and easily positioned, preferably by one person. Vertical temperature profiles are very important for the derivation of air mass stability and a variety of towers and masts have been used to mount instruments near the point of spray emission or near tree-top height (Armstrong 1971, Armstrong and Beveridge 1974, Blais et al. 1980, DeBoo and Campbell 1972, Foisy et al. 1976).

This report will summarize the development of a weather measurement system designed specifically for aerial spray experimentation. Although the system as presented may be inadequate or incomplete for other forestry uses, the appropriate modifications and adaptations are left to the imagination and needs of the user. Also, because of rapidly escalating costs and the constant development of new and improved instruments, the reader is advised to contact either local AES staff or the authors for specific information related to items discussed. In keeping with the policies of the British Columbia Ministry of Forests and the Canadian Forestry Service, mention of trade names and proprietary products implies neither exclusive recommendation nor endorsement.

MATERIALS AND METHODS

Meteorological Considerations

Ideally, as many factors as possible should be considered in the appraisal of weather conditions for spraying at a representative ground station. Minimum considerations should include:

1) Temperature at two vertical locations, one near the top of a portable mast or tower, the other at about one meter above ground to determine air mass stability according to Armstrong (1977, 1979).
2) Relative humidity preferably read near the upper temperature probe using a remote psychrometer (Beveridge 1983) or by conventional psychrometer near the lower probe.
3) Wind speed and direction near the top of the mast.

Such information should be recorded on an appropriate tally form suitable to the needs of the operation (Fig. 1).

WEATHER RECORDS

PROJECT
Spruce budworm
RECORDER
R.F.D.

DATE May 29/79 BLOCK NO. X-23
LOCATION C.F.B. Gagetown N.B.
TREATMENT Aminocarb
AIRCRAFT CG - PKG
CONFIGURATION Microngir

APPLICATION			
NO.	START	STOP	SWATHS
1	0548	0610	11
2	0635	0655	10
3	0720	0747	12

TIME	TEMP. °C		R.H. %	WIND (km/hr.)			% CLOUD COVER	REMARKS
	upper	lower		range	max.	direction		
0515	9	7	93	0-3	5	270	100	inversion - trees dry
0530	9	7	93	0-2	3	270	100	"
0545	9	7	90	0-2	2	270	100	"
0600	9	7	90	1-3	5	280	100	"
0615	9	7	87	2-4	5	280	90	briefly sunny
0630	9	8	85	2-4	7	270	90	
0645	9	8	85	2-4	5	270	90	
0700	9	8	80	1-4	5	250	90	
0715	9	9	80	0-3	3	250	75	
0730	9	9	82	2-4	5	270	75	
0745	9	9	77	2-6	8	270	75	

FIGURE 1

Additional readings can be acquired from sensing devices located at other elevations on the mast and from installations in the spray aircraft. Thus readings can be acquired to provide detail from the zone of droplet generation, through the forest canopy, to near ground level. Other criteria such as percent and type of cloud cover and tree foliage condition (i.e. wet, dry) can be recorded by the station operator. Calculation and/or close estimation of off-target drift potential, evaporation rate, air mass stability, and wind turbulence can then be made on site to determine (1) the feasibility of initiating aerial spray operations, (2) the time to discontinue applications as weather deteriorates, and (3) subsequent analyses of relationships between droplet deposit and foliage protection (in the case of insecticide application to control defoliators).

The periodic and systematic recording of such data should ideally be taken from instrument sensors placed within the forest spray block from below crown cover to about 10 m above tree tops. However, because inaccessibility and other logistical limitations usually prevent such installations, a suitable location within a nearby clearing (minimum diameter ca. 10 x height of nearby trees) can be selected as an alternative site. There, some parameters such as wind velocity (Silversides 1978) and Stability Ratio (Armstrong 1979) for the spray block can be calculated using conversion ratios or interpolated with accuracy from the representative readings.

Meteorological Equipment

Reliable meteorological instruments can be obtained from a variety of sources, including:

1) Environment Canada, Atmospheric Environment Service, 4905 Dufferin Street, Downsview, Ontario M5H 5T4;
2) Weather Measure Corporation, P.O. Box 41257, Sacramento, California 95841;
3) Canadian Forestry Equipment Co., 11004-166A Street, Edmonton, Alberta T5P 4H6;
4) Forestry Suppliers, Inc., West Rankin St./Box 8397, Jackson, Mississippi 39204;

From the available instruments and equipment, the following items were selected for the topic mobile system:

1) The Heathkit^{R} model ID-4001 digital weather computer and accessories (2 thermistors, cup anemometer, wind vane, barometer) from the Heath Company, 1480 Dundas Street East, Mississauga, Ontario L4X 2R7;
2) A Bendix Model 566 fan psychrometer from Fisher Scientific Company, 184 Railside Road, Don Mills, Ontario M3A 1A9;
3) Four ca. 3 m long sections of aluminum mast tubing of 2.5, 3.75, 5.0, and 7.5 cm outside diameter and 3 mm wall thickness from Drummond McCall and Company, Limited, P.O. Box 219, Stn. A, Montreal, Quebec H3C 2S4 (Branches in other major cities).

4) Multi-conductor electrical cable and connectors; ca. 5 cm square steel tubing for the mast support bracket, nylon guides for each telescopic mast section, a DC to AC power inverter (40 to 60 watt range is adequate), laboratory clamps, plastic tie-wraps, and miscellaneous other materials and hardware acquired from local retail suppliers.

Installation

The configuration of sensing devices and related equipment is arranged for rapid assembly by a single person at the temporary site. Transportation to site is by 4-wheel drive pick-up, which transported the mast to the station site on support brackets attached to the side of the fibreglass box cap. Instruments are carried in specially-constructed equipment boxes in the rear of the vehicle; the Heathkit computer is housed in a protective container mounted to the cab wall behind the seat bench.

After arrival at the selected site, the station operator positions a lightweight support stand (or an empty equipment box) about 8 m forward of the bumper-mounted vertical-support mast bracket. The mast is then connected to the bottom of this bracket by a heavy-dufy hinge pin, extended to full length to rest on the support stand, and fastened by safety support pins inserted between each pair of interlocking mast sections. Weather-measuring devices and associated equipment are then positioned and mounted at the uppermost extremity and electrical connections made to the computer via a connector installed in the radiator grill of the vehicle. The wire cable is secured to the mast by plastic tie-wraps. With all instruments in place and secured, the operator then carefully lifts the tower, and raises it to the vertical position, where a sliding clamp is placed over the top of the square-tube steel bumper bracket to secure the mast in the vertical position.

The lower temperature probe is mounted at ca. 1 m above ground on a staked aluminum pole located several m upwind and away from any heating influence of the vehicle. The fan psychrometer is placed nearby for readings at a similar elevation. Finally, the computer unit is turned on by switching on the power inverter mounted nearby. The weather station is then functional after a suitable warming-up period. (Fig. 2).

Appraisal

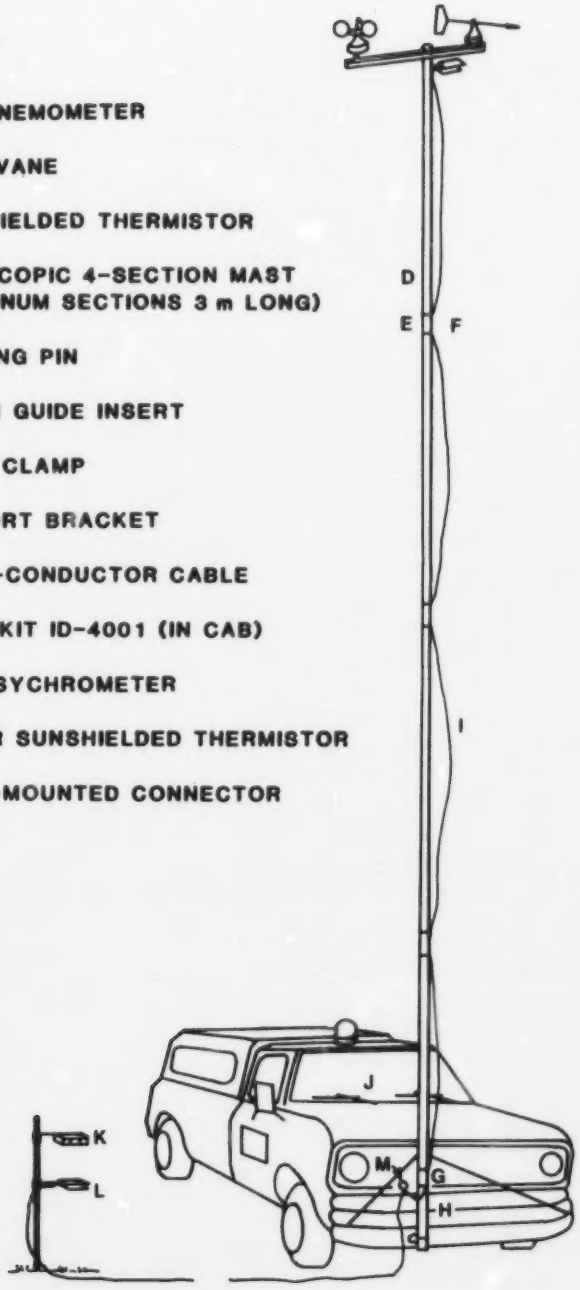
The Heathkit unit was initially calibrated, and readings compared with those from AES instruments, at an airport facility near Sault Ste. Marie, Ontario.

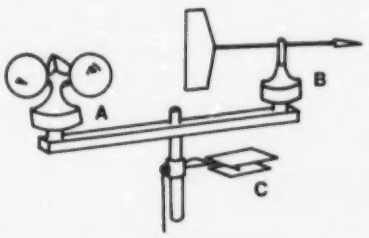
Preliminary evaluation of the system was undertaken during an experimental aerial spray program in southern New Brunswick.

FIGURE 2

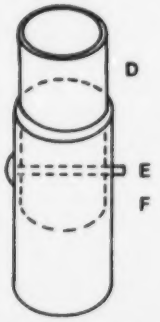
LEGEND

- A CUP ANEMOMETER
- B WIND VANE
- C SUNSHIELDED THERMISTOR
- D TELESCOPIC 4-SECTION MAST (ALUMINUM SECTIONS 3 m LONG)
- E LOCKING PIN
- F NYLON GUIDE INSERT
- G SLIDE CLAMP
- H SUPPORT BRACKET
- I MULTI-CONDUCTOR CABLE
- J HEATHKIT ID-4001 (IN CAB)
- K FAN PSYCHROMETER
- L LOWER SUNSHIELDED THERMISTOR
- M GRILL-MOUNTED CONNECTOR

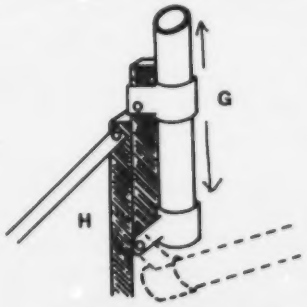




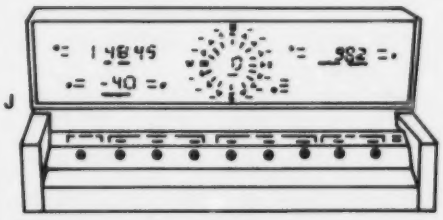
BASIC WEATHER-MEASURE DEVICES



TELESCOPIC MAST SECTIONS



BUMPER-MOUNTED SUPPORT BRACKET



HEATHKIT ID-4001 DISPLAY PANEL

EVALUATION AND DISCUSSION

Construction, Calibration and Comparison

Construction of the Heathkit model ID-4001 took about 20 hours of concentrated work by an experienced person following an instruction booklet. Quality of components was found to be very good and no special tools were required. The telescopic tower and associated brackets were assembled and installed by local commercial machine shops. Electrical wiring harnesses, the protective housing of the computer/display component, and other vehicle installations were made by technical support staff at the Forest Pest Management Institute.

Following instructions given in the operations manual provided, calibration of the Heathkit weather computer was quick and simple. The most involved calibration was the adjustment of the two temperature probes at $0^{o}C$ utilizing a container of ice and water. However, some judgement was required in synchronizing the two probes as the display panel did not read in fractions. Coefficients of correlation for three actual outdoor temperature groupings from 0^{o} to $15^{o}C$ showed good reliability when compared with sheltered liquid mercury thermometer readings of the AES office at the Sault Ste. Marie airport. Correlations for both thermistors fell within the range of $r = 0.958$ to $r = 0.996$.

Wind speed and direction as recorded by the Heath unit within the range 0-22 km/hr also were quite similar to those of the AES instruments. Differences of 2-3 km were noted during turbulent conditions, but this decreased as wind speed stabilized. The Heath wind-measuring component was considered as reliable as any other types previously used.

Records of barometric pressure from 995 to 1021 millibars and indications of pressure variations were identical for both Heath and AES instruments.

Field Evaluation

An opportunity to evaluate the system occurred during a study of aerial spray applications in southern New Brunswick during 1979[1]. The mobile system, as described, was utilized for a total of 24 sprays spanning a period of 9 days. Spray blocks ranged from 10 to near 30 km by road from the airport base at Blissville, where a standard AES-type weather station was established as backup.

The mobile station was usually positioned on pre-determined sites about one hour before the first aircraft lift-off. Weather information, as exemplified in Fig. 1, was recorded as soon as installations were made and continued until 15 to 30 minutes after application of the final spray swath, a period usually of 2-4 hours duration. The system was assembled within 30 minutes of arrival, and usually disassembled and stored in about 20 minutes.

Using a ground-to-ground FM radio network, communication was possible with other field units and with the airport operations base at all times. Ground to air communication was also by radio and by flashing strobe light[2] as required. Thus, the temporary field site served as a command centre to (1) make weather information available to key personnel at all times; (2) initiate the spray operation; (3) monitor weather conditions during application; and (4) determine when to conclude the operation based on deteriorating weather factors. This system, operated at all times by a single individual, functioned without any problem for the duration of 24 experimental spray trials.

In years past, erection and guying of masts usually required the input of two persons for about twice as long. The second individual, although needed only temporarily, usually could be deployed elsewhere, and his/her presence usually tied up a second vehicle temporarily as well. The new semi-computerized mobile system, as accurate as all others used during previous experiments, had the major advantage of economy of manpower and time. Depending upon logistics and need, the mobile system could be used at more than one location during a given spray session as well—a major improvement over other systems.

The versatility of the mobile weather system should be apparent to both research and operations personnel. Contained in a suitable 4-wheel drive vehicle, access to many areas was possible even under springtime forest road and trail conditions.

Although higher elevations for mounting equipment may be possible through the use of heavier materials and power-assist equipment, the current configuration should be retained in the interests of speed and simplicity. The versatility of the telescopic mast component is indicated by the addition of other equipment such as radio antennae and the strobe light. Other instruments such as the remote psychrometer and a bivane turbulence indicator can be attached provided the terminal weight factor remains reasonable for the operator to handle. Specific uses of the system should be unlimited—fire research, operational spray programs, pollution control studies, and other situations requiring reliable measurement of weather parameters.

[1] DeBoo, R.F. 1983. Efficacy of chlorpyrifos-methyl for control of spruce budworm, Choristoneura fumiferana (Clem.) (Lepidoptera: Tortricidae) B.C. For. Serv. Int. Rep. PM-PB-7, 18 pp.

[2] Series 30-0437-100 anti-collision light from Standard Aero Ltd., Winnipeg International Airport, Winnipeg, Man. R2R 0S8 (Brs. other major cities).

SUMMARY AND CONCLUSION

A mobile weather-measurement system as required for experimental aerial spray applications was constructed, calibrated, and evaluated under field conditions. Major components included a telescopic 4-section mast, a Heathkit model ID-4001 weather computer and sensing devices, and an extended-cab 4-wheel drive pickup truck. The system functioned accurately and well under field conditions during a calibration-comparison study near Sault Ste. Marie, Ontario, and during an experimental aerial spray program in southern New Brunswick. These trials indicated not only that the system was well adapted to weather monitoring during operational spray applications, but also that with minor modifications, its uses might be readily expanded for related field purposes.

ACKNOWLEDGEMENTS

The assumption that better knowledge of weather conditions leads to better understanding of aerial spray results has been a research cornerstone of the Forest Pest Management Institute and its antecedent, the Chemical Control Research Institute, for many years. We acknowledge the leadership of J.A. Armstrong in both stressing this dictum across Canada and in promoting the use of appropriate weather instruments through field investigations and demonstrations during the past decade.

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